International Journal of Communication Networks and Information Security
ISSN: 2073-607X, 2076-0930
Volume 15 Issue 02 Year 2023

Analysis of Regional Characteristics of Jinnan Folk Paper-cutting by Dynamic Programming Algorithm

Jimin Li
Doctor, Department of Fine Arts, International College, Krirk University, Bangkok, 10220, Thailand
418244547@qq.com
Guoyun Zhang*
Professor, Department of Fine Arts, International College, Krirk University, Bangkok，10220, Thailand
zhangguoyun@scfai.edu.cn

Article History

Received: 11 May 2023
Revised: 30 June 2023
Accepted: 21 July 2023

Abstract

In Southern Jinnan, the distinctive regional attributes significantly influence the evolution of folk paper-cutting, transforming it into a cultural focal point. However, the analysis of this art form is often compromised by inadequate data and subpar analytical techniques, primarily due to the region's lagging wireless network infrastructure. Such technological shortcomings hinder the comprehensive development of the paper-cutting tradition. To counteract these issues, this paper introduces a sophisticated method for analyzing folk paper-cutting features using dynamic programming. This method first employs collaborative wireless communication technology to gather extensive data on the paper-cutting practices across different areas. It then applies dynamic programming to consolidate this data, enabling a nuanced regional classification based on specific folklore characteristics while maintaining their intrinsic commonalities. Subsequently, dynamic call wireless communication technology is utilized to transmit these regional features, promoting the harmonization of folk paper-cutting traits. The analytical results are promising, demonstrating that the support of collaborative wireless communication, coupled with dynamic programming, substantially upgrades the quality of folk paper-cutting in Southern Jinnan. This method not only fosters the cultural enrichment of the paper-cutting craft but also aligns with the cultural construction requirements of Jinnan, indicating a successful integration of traditional artistry with modern technological advancements.

Keywords: Dynamic Programming, Jinnan, Folk Custom, Decoupage, Regional Characteristics, Data Fusion, Data Standardization, Data Shunting

1. Introduction

Collaborative wireless communication is a signal relay between multiple clients[1], which enhances the speed and stability of signal transmission[2], realizes the processing of massive data, and can greatly improve the effective transmission of data in different regions[3]. However, when

carrying out collaborative wireless communication[4], the problems of complex data and frequent interference often occur, which affect the characteristic analysis of Jinnan folk paper cutting. Therefore, this paper integrates the dynamic programming method with collaborative wireless communication to analyze the characteristics of folk paper-cutting in different regions, extract the key values therein, and better integrate them. In the past year, the analysis of regional characteristics of Jinnan ethnic papercutting has shown a dynamic trend, and the specific results are shown in Figure 1.

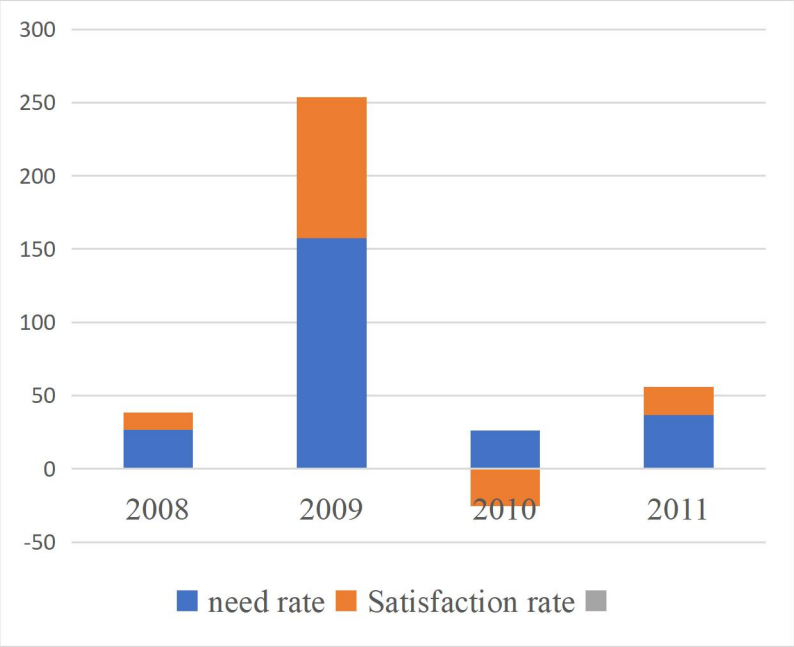

Figure 1. Regional Characteristics of Jinnan Ethnic Paper-cutting (Data Source: Jinnan folk literature, regional survey report)

Collaborative wireless communication is a communication method based on self-organizing network[5], which can realize relay transmission, provide multi-terminal communication requirements for information transmission[6], reduce the loss rate of transmission, and realize the efficient use of communication resources[7], and stable communication transmission. Therefore, collaborative wireless communication provides basic conditions for the characteristic analysis of Jinnan folk paper-cutting in different regions, and the improvement rate of collaborative wireless communication is shown in Table 1.

Table 1. Improvement of Indicators of Collaborative Wireless Communication (unit: %)

Index	Performance	Error
Transfer efficiency	44.95	25.09
Relay point switching	14.95	14.93
Transmission distance	25.10	54.88
Transmission volume	15.06	24.96

The communication process of collaborative wireless communication is shown in Figure 2.

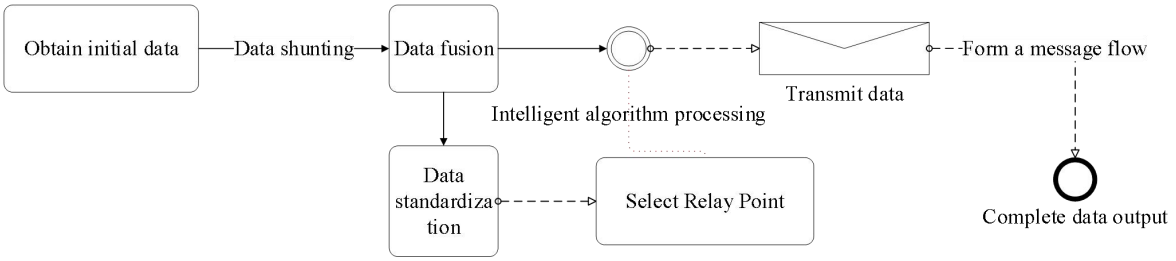

Figure 2. The Fusion Process of Jinnan Folk Paper-cutting Data under Collaborative Wireless Communication

Leveraging the high terminal engagement and broad-scale deployment capabilities of collaborative wireless communication[8], it adeptly captures and disseminates the nuanced content and regional distinctions of Jinnan's folk paper-cutting traditions[9]. By integrating dynamic programming, the methodology streamlines the extraction and distribution of these cultural features. Concurrently, an in-depth examination of Jinnan's paper-cutting cultural meanings and traits is conducted to assess the collaborative wireless system's performance and the fidelity of the data relayed. The findings reveal that dynamic programming significantly elevates the accuracy in identifying Jinnan's folk paper-cutting attributes[10], while also reducing the complexity and scale of data in wireless transmission. This dual-technique approach is applied to analyze the folk paper-cutting features, drawing comparisons between the art form's regional variations. During this characteristic analysis of the Jinnan folk paper-cutting domain[11], the transmission quality is prioritized, necessitating the strategic selection of relay points to optimize transmission efficacy, as systematically detailed in Table 2's guide to trunk endpoint selection.

Table 2. Relay Point Selection for Coordinated Wireless Communication

Content	Server	Relay Point Selection
Text, documents, and web pages	3	5
Video files	4、5	3
Oversized files	6	2

As can be seen from the description in Table 2, collaborative wireless communication can select servers and relay points according to the amount of transmitted data. Although it can quickly transmit Jinnan folk paper-cutting data in different regions, it cannot realize regional feature identification, classification[12], mining and elimination, which is not conducive to the summary of paper-cutting regional characteristics and the adjustment of relevant parameters. Therefore, it is necessary to use dynamic programming to assist[13].

2. Literature Review

2.1 Identification of Different Regional Characteristics of Jinnan Folk Paper-cutting Data

Regional feature identification mainly starts from the content, color and structure, and the dynamic programming method excavates the feature data[14], reduces the characteristic indicators of the region, and aggregates the characteristics in different regions Add correlation values, impact values, and development values. The combination of regional feature identification and dynamic programming can transmit massive regional feature data and reduce the amount of network transmission. The dynamic programming method can set the frequency band matching, endpoint, and transmission amount of folk paper cutting and regional characteristic data, and the specific transmission process is as follows.

Regional data of Jinnan folk paper-cutting: Jinnan folk paper-cutting data is a_i, the content characteristics is b_i, the structural characteristics is c_i, the regional characteristics calculation function is $ro(x_i)$, and the importance of the characteristics is the regional data of Jinnan folk paper-cutting w_i.The collection is shown in Equation (1):

$$set(k) = \sum a_i + b_i + c_i \tag{1}$$

The process of zone characteristics is as follows:

```
for{tz Synergy;
    set Synergy =i;
while{tz i=i+1}
    do{download = Synergy;
     open = a;
     Other load(sql)}}
```

From the above programming code, the regional feature recognition of Jinnan folk paper cutting can be realized, and the collaborative wireless port selection can be carried out according to the characteristics to improve the transmission efficiency of the features. Sorting of regional characteristic indicators: weight sorting function is $lin(w)$, feature influence degree calculation function is $A(w)$, regional feature index fusion degree sorting is $B(w)$, dynamic programming method sorting result is g , regional feature index sorting is sorting As shown in Equation (2):

$$g = \frac{A(x) \cdot B(x)}{i} \tag{2}$$

The process of sorting regional characteristic indicators is as follows:

```
while{void qz(x)
      { IF{ qz< x;
      Then qz= y;
       into sql
} }
```

Transmission of Jinnan folk paper-cutting data by collaborative wireless communication: the wireless transmission node is dot_i, the node transmission function is $put(x)$, the collaborative transmission function of the characteristic data is $toh(x)$, and the regional feature processing process of Jinnan folk paper-cutting is shown in Equation (3):

$$toh(x) = put(x) \times dot_i \tag{3}$$

3. Methodology

3.1 Collaborative Wireless Transmission Processing of Regional Characteristic Data

The data pertaining to the regional characteristics of Jinnan's folk paper-cutting exhibit inter-regional variability, necessitating encryption to pinpoint crucial content and its contextual relevance. Moreover, the efficiency of data transmission for Jinnan's folk paper-cutting is affected by the utilization rate of the transmitting terminal and the latency in relay stages [12]. Therefore, it is imperative to filter out non-essential paper-cutting content to streamline the data processing for this cultural expression.

In order to analyze the regional characteristics more reasonably, it is necessary to select the nearest relay end, and the processing results are shown in Table 3.

Table 3. Selection Rate of Jinnan Folk Paper-cutting Relay End

Transfer Content / The Type of Data	Relay Point Number	Color	Structure	Content	Utilization Rate
Structure class data	3	64.94	65.00	64.98	84.92
	36	64.70	64.95	64.90	84.92
	34	65.26	65.08	65.20	84.87
	24	64.78	64.73	64.71	84.91
	6	64.95	65.13	65.03	84.86
Unstructured data	39	64.98	65.00	65.20	85.10
	9	65.18	65.01	65.25	84.98
	21	64.76	65.03	65.05	85.03
	18	64.88	65.01	64.96	84.97
	29	64.88	64.91	64.91	85.09

Transfer Content / The Type of Data	Relay Point Number	Color	Structure	Content	Utilization Rate
Semi-structured data	38	65.11	64.88	65.07	85.12
	11	64.88	64.98	64.72	84.88
	12	64.96	65.11	65.07	85.00
	17	64.94	65.00	64.98	84.98

From the identification of the characteristics of the paper-cutting area in Table 3, it can be seen that the data transmission integrity of regional culture, paper-cutting method, paper-cutting structure and paper-cutting material is good, indicating that the operation of each collaborative terminal is good.

3.2 Matrix Processing of Regional Feature Data

The data in Table 3 are dynamically programmed and the matrix values of each planning class are shown in Table 4.

Table 4. Dynamic Programming Matrix for Regional Characteristics

Test / Relay Point Number	Regional Culture	Paper Cutting Method	Paper Cut Structure	Paper Cut Material
3	1	0.38769	0.22547	0.68585
36	0.4173	0.26744	0.24742	0.54715
34	0.35231	0.71203	0.04746	0.88245
24	0.49342	0.78432	0.17539	0
6	0	0.45272	0	1
39	0.26894	0.651	0.95171	0.69203
9	0.26449	0.3796	0.48391	0.69975
21	0.77157	0.30642	0.64837	0.75014
18	0.63369	0.44067	0.42087	0.71278
29	0.90582	0.5161	0.88149	0.46211
38	0.91278	0.3153	1	0.38111
11	0.64326	0	0.08847	0.64079
12	0.56597	0.56098	0.559	0.957
17	0.37522	1	0.47404	0.74782

As can be seen from the data in Table 4, the identification matrix eigenvalues of the dynamic programming method < 1, indicate that there are eigenvalues in the matrix. It also indirectly shows that after the processing of dynamic programming method, the regional feature values exist, and there are no abnormal feature values or false feature values, which meet the transmission requirements of collaborative wireless communication. There are great differences in the regional characteristics of Jinnan folk paper-cutting, and the wireless data transmission between regions > 0.042 seconds, indicating that the complexity of regional characteristic data and the proportion of natural language are large, and the complexity of transmitted data needs to be simplified. In addition, the feature data processing capacity of the dynamic programming method > 80%, while the transmission volume of regional feature data is only 25%, which further indicates that the regional feature data should be simplified.

4. Results and Discussion

4.1 Conditions for Collaborative Wireless Communication

Based on collaborative wireless communication, this paper analyzes the content, method and form based on the characteristics of Jinnan folk paper cutting. For detailed experimental analysis, the work employs 32 terminals such as PAD, WIFI, LAN, 4 servers, and PCs 45 computers, the transmission frequency is 12~45Hz, and the Jinnan paper-cutting content is .pad, .jpg and other formats, the specific conditions are shown in Table 5.

Table 5. Hardware Conditions for Collaborative Wireless Communication

Parameter	Content	Transmission Side
Transfer rate	45Gpisc、23.4Hz	4~6pcs
Transfer format	Text, pictures, videos	6~11pcs
Transmission volume	32TG~45TG	2~8pcs
Single shot file format	0.6G	6~10pcs

The sampling results of collaborative wireless communication are shown in Figure 3.

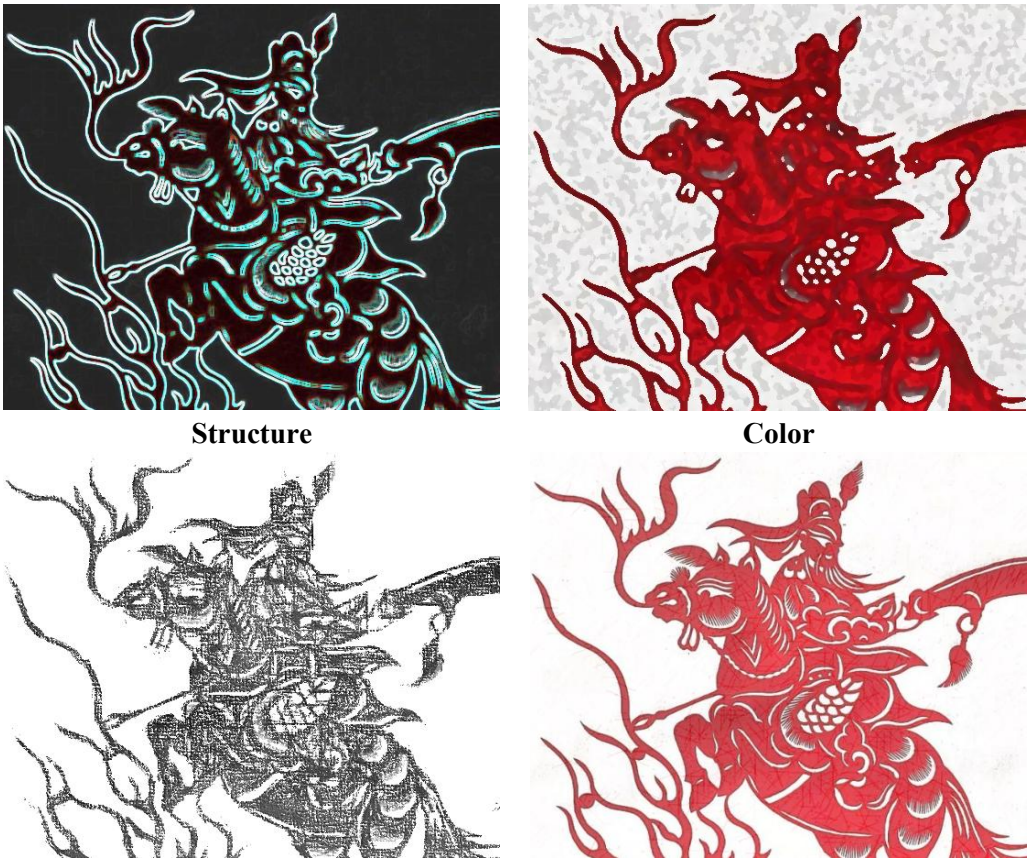

Figure 3. Sampling Results of Jinnan Folk Paper-cutting

Figure 3 shows the basic and actual display effects of Jinnan folk paper-cutting, and the basic data, as the framework of Jinnan folk paper-cutting, mainly displays regional characteristics, and regional characteristics are composed of content and form. The comparison results in Figure 3 show that collaborative wireless communication can improve the regional characteristic effect of folk paper-cutting, present folk customs and content, and more accurately realize the fusion of regional characteristic data. It shows that the characteristic analysis effect of collaborative wireless communication is ideal, and the specific data overview is shown in Table 6.

Table 6. Overview of the Characteristics Analysis of Jinnan Folk Paper-Cutting

Jinnan Folk Paper Cutting Content	Research Directions	The Number of Characteristic Indicators	The Specificity of the Feature
Geographical characteristics	Jinnan	3	73.98
	ethnic group	9	69.73
Folklore characteristics	trappings	8	74.31
	diet	9	75.82
	tourism	8	81.09
Content characteristics	tradition	7	76.27
	custom	9	72.59

4.2 Feature Extraction Process of Jinnan Folk Paper-cutting

The characteristic analysis rules are the characteristic analysis measures of Jinnan folk paper-cutting, which can deeply analyze the characteristic analysis effect of Jinnan folk paper-cutting, as well as the specific implementation Table 7 shows the specific identification results.

Table 7. Feature Extraction of Jinnan Folk Paper-cutting

Identification Method	Characteristic Indicators	The Degree of Feature Analysis
Content characterization	Single structure	71.85
	color	72.59
	generality	81.12
	personality	73.71
	Regional	70.68
	Visual features	72.02
	Sensory features	70.01
	Behavioral characteristics	74.48
	Concept features	79.91
	Connotative characteristics	78.43
Paper cut features	symbol	68.58
	dimension	65.81
	image	73.65
	Characteristics of the times	72.06
	Vintage sex	75.97
The number of indexes	14	
maximum	85.12	
Maximum range of change	15.14	
The maximum magnitude of change	50.73	

The feature extraction results in Table 7 show that the degree of features is close to 10 times, indicating that cooperative wireless communication can meet the actual characteristics and make it reach 10 times more. The change process of Jinnan folk paper-cutting characteristics is shown in Figure 4.

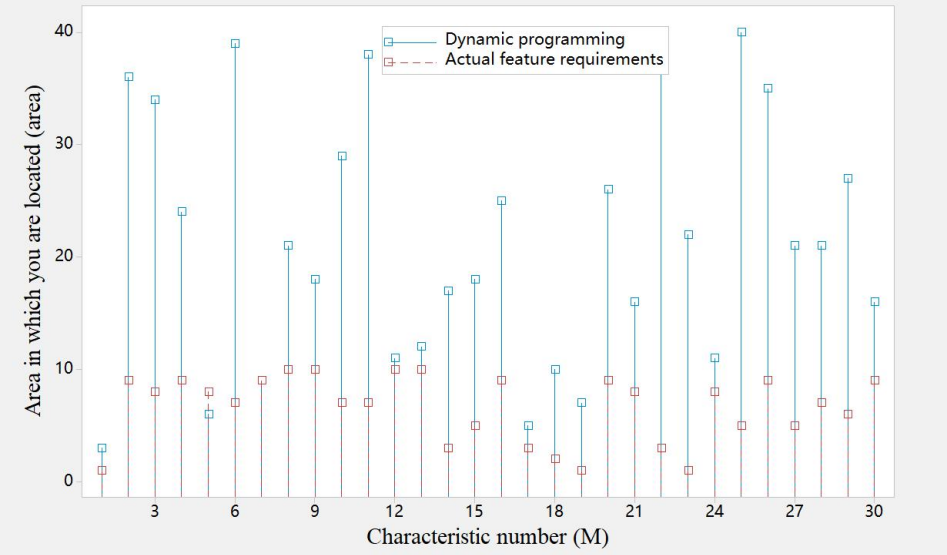

Figure 4. Regional Characteristics Judgment Process of Jinnan Folk Paper-cutting

As depicted in Figure 4, the methodology introduced in this study demonstrates a significant capacity for representing Jinnan's folk paper-cutting, with data characterization success exceeding 70% during the process and showing an upward trend. This proficiency is primarily attributed to the incorporation of dynamic programming techniques, which streamline the volume of data transmitted during the initial stages of Jinnan folk paper-cutting events, and enhance the data transfer rate while minimizing server load in the collaborative wireless communication framework, thus facilitating the real-time rendering of folk paper-cutting patterns.

4.3 Feature Recognition Rate of Folk Paper Cutting

Alterations in Jinnan's folk paper-cutting practices influence various aspects such as color rendition, data transfer, port adaptability, wireless transmission speeds, and frequency band usage. Consequently, it is advisable to mitigate the frequency of these changes to maintain system integrity and performance. Detailed outcomes of this recommendation are systematically presented in Table 8.

Table 8. Feature Recognition Rate of Folk Paper-cutting

Index	Content	Color	Compatible Data	Key Content	Transfer Point	Key
Common characteristics	ethnic group	65.08	65.10	64.91	64.87	84.96
	folk custom	65.05	64.81	65.35	54.90	85.12
Regional characteristics	ethnic group	64.80	65.02	64.92	74.74	84.99
	folk custom	65.04	65.14	65.19	54.98	85.02

The changes in area feature recognition in Table 8 are shown in Figure 5.

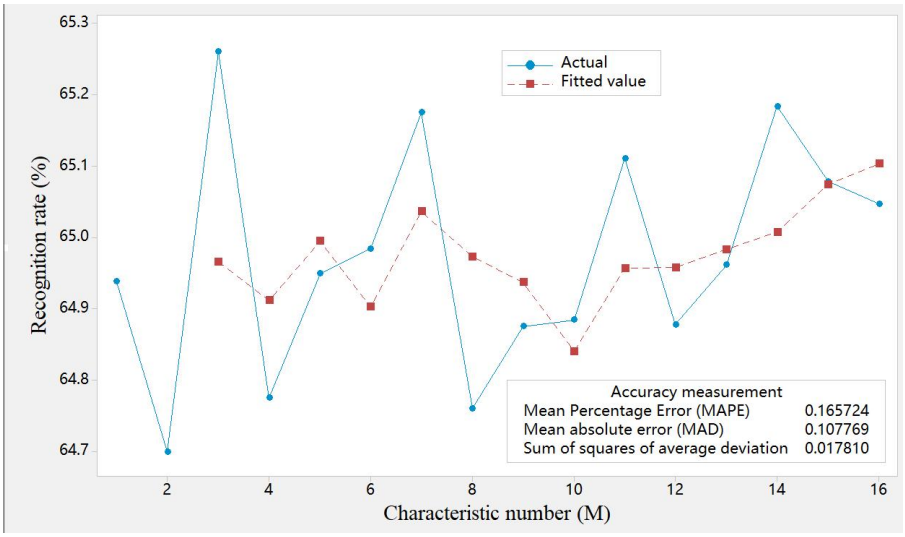

Figure 5. Changes in the Feature Recognition of Jinnan Folk Paper-cutting

Figure 5 illustrates that the intrinsic and regional traits of Jinnan's folk paper-cutting exhibit minimal variance across different levels of feature recognition, suggesting that alterations within Jinnan's paper-cutting tradition have a negligible effect on the art's core content. Moreover, the stability of these common characteristics underscores a fundamental consistency that remains unaffected by the changes, reinforcing the notion that the dynamic programming approach is adept at effectively representing the evolving cultural narrative of Southern Jinnan's paper-cutting heritage. This is attributed to the method's ability to decrease transmission errors via streamlined data conveyance, reduce the time required for data analysis of Jinnan's folk paper-cutting, and enhance the volume of data transmitted per cycle, thereby satisfying the analytical demands for regional characteristic assessment with precision.

4.4 Collaborative Wireless Network Endpoint Selection Effect

The efficacy of selection plays a pivotal role in the analysis of Jinnan folk paper-cutting features. It's essential to implement multi-endpoint sampling for identifying characteristic points, document the real-world display outcomes, and conduct comparative assessments. Detailed findings of this process are depicted in Figure 6.

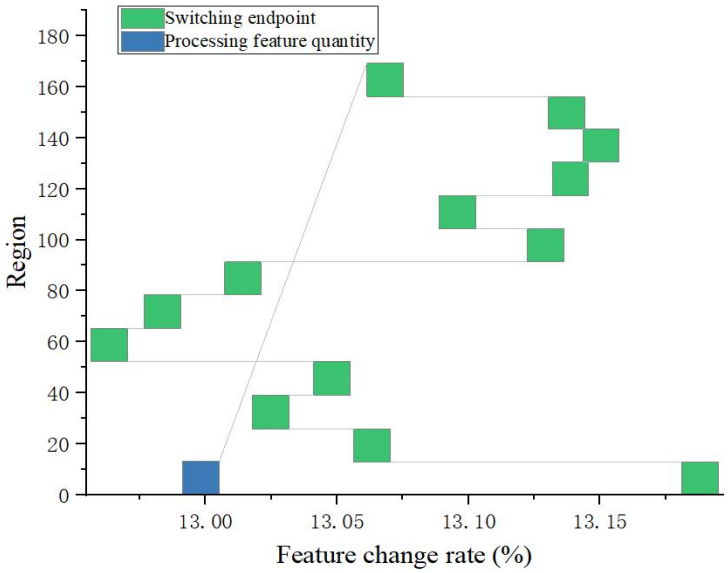

Figure 6. Endpoint Selection Effect of Jinnan Folk Paper-cutting Feature Analysis

Figure 6 reveals that relay endpoints are distributed broadly, with selection effect data aggregating from the extremities towards the center. This pattern indicates a significant variance between relay points and feature quantities, suggesting that relay endpoints are capable of fulfilling actual transmission needs. The data's dispersion on either side is attributed to the transformation and characteristics representing two distinct data sets moving in different directions, leading to iterative changes along their respective trajectories, thereby facilitating enhanced iterative computations. These observations confirm that the dynamic programming approach can effectively strategize the content of Jinnan folk paper-cutting and bolster the capabilities of collaborative network communication. Analyzing the data presented in Figure 6 yields specific computational results, which are detailed in Table 9.

Table 9. Endpoint Selection Effect of Jinnan Folk Paper-cutting

Endpoint	Parameter	Endpoint Occupancy	Fusion Effect	Convergence Metrics
Random endpoints	Content characteristics	68.86	77.35	7
	Color blending	69.48	70.96	7
	Common characteristics change	79.40	73.59	10
Fixed endpoints	Content characteristics	80.05	73.12	10
	Color blending	75.33	76.88	3
	Common characteristics change	74.35	74.80	5

Upon analyzing both fixed and random endpoint outcomes, it was observed that the recovery rate for test packets involving content characteristics, color integration, and common feature alterations exceeded 80% throughout the entire sampling recognition process. The reception's selection effectiveness reached 90%, with a progressive probability surpassing 70%. These findings suggest that in varying sampling scenarios, the actual display outcomes of Jinnan folk paper-cutting exhibit minimal discrepancies. The high selection effectiveness and recovery rates, exceeding 80%, further demonstrate that collaborative wireless communication is capable of facilitating real-time data transmission for Jinnan folk paper-cutting. Moreover, this technology provides robust wireless data support for feature recognition in Jinnan folk paper-cutting, accommodating the fluctuations in regional characteristic data.

4.5 Accuracy of Regional Characteristics

The proposed method is validated based on the Transmission accuracy which is the adherence of the projected data source with the original source. The varied nature of Jinnan folk paper-cutting, its intricate cultural expressions, and the amalgamation of diverse colors necessitate precise network parameters to accurately assess the fidelity of Jinnan folk paper-cutting representations. The outcomes of this assessment, demonstrating the critical role of network accuracy in evaluating the authenticity of these cultural artifacts, are illustrated in Figure 7.

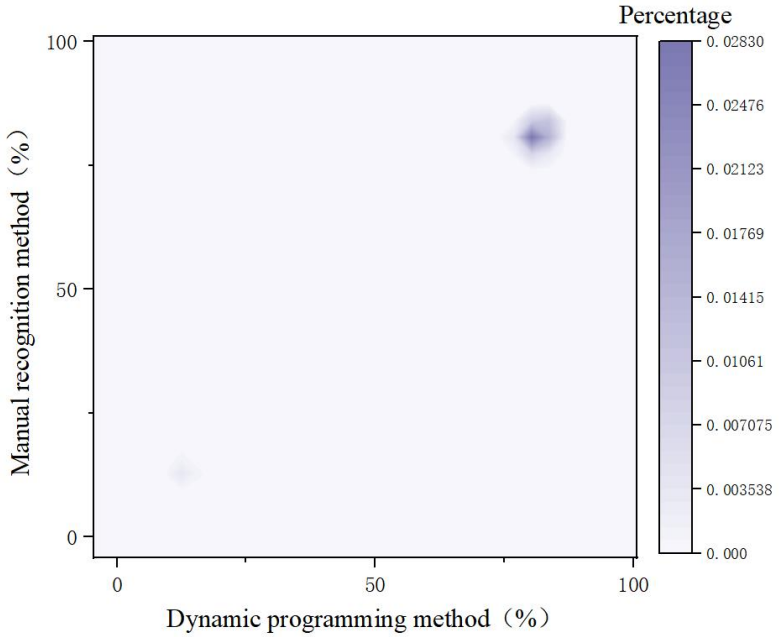

Figure 7. Transmission Accuracy of Jinnan Folk Paper-cutting Feature Recognition

Figure 7 indicates that the transmission precision of the dynamic programming approach surpasses that of manual identification methods. The transmission outcomes for each Jinnan folk paper-cutting piece closely align with their actual presentations, suggesting that collaborative wireless communication can accurately complete feature extraction. This provides extensive support for the representation of Jinnan folk paper-cutting, with detailed results presented in Table 10.

Table 10. Recognition Accuracy of Jinnan Folk Paper-cutting Features

Extract Location	**The Dynamic Programming Algorithm Processes the Results**		**Coordinated Wireless Communication Transmits Results**	
	ethnic group	folk custom	ethnic group	folk custom
77°82”	81.58	80.54	84.12	76.86
35°05”	81.41	82.93	80.14	79.98
16°41”	81.19	80.54	86.12	82.85
56°73”	80.86	78.98	79.90	84.10
54°52”	83.09	83.12	79.19	79.74
25°85”	83.12	83.48	80.89	83.42
12°43”	80.29	81.06	81.51	79.64
22°94”	82.48	80.23	77.70	80.02
17°01”	80.54	79.53	78.54	78.15

Table 10's analysis reveals that the identification of regional traits in Jinnan folk paper-cutting is notably effective, with the transmission rate of collaborative wireless communication exceeding 80%. This efficiency primarily stems from the dynamic programming method's extraction of regional feature data, which simplifies the data complexity in collaborative wireless communication. This evidence supports the conclusion that collaborative wireless communication transmission is capable of fulfilling practical demands. Additionally, the selection process of the relay terminal encountered no abnormal disruptions, signifying an optimal transmission effect for the characteristics of Jinnan folk paper-cutting.

5. Conclusion

This study introduces a dynamic programming-based method for extracting regional features in folk paper-cutting, employing collaborative communication technology to achieve a transmission rate of 10Gbps. Testing indicates that the accuracy of transmissions using this technology exceeds

90%. The dynamic programming approach effectively selects relay points, with a transmission compliance rate surpassing 80%, thereby fulfilling the requirements for regional feature extraction. Consequently, the combination of dynamic programming methods and collaborative communication technology effectively facilitates the extraction of regional characteristics, contributing to the advancement of Jinnan folk paper-cutting.

References

[1] A. Badica, C. Badica, I. Buligiu, L. I. Ciora, and D. Logofatu, "Dynamic Programming Algorithms for Computing Optimal Knockout Tournaments," *Mathematics*, vol. 9, no. 19, 2021.

[2] M. Bandarra, and V. Guigues, "Single cut and multicut stochastic dual dynamic programming with cut selection for multistage stochastic linear programs: convergence proof and numerical experiments," *Computational Management Science*, vol. 18, no. 2, pp. 125-148, 2021.

[3] S. Chen, M. H. Hu, and S. Q. Guo, "Fast Dynamic-programming Algorithm for Solving Global Optimization Problems of Hybrid Electric Vehicles," *Energy*, vol. 273, 2023.

[4] Z. L. Feng, Z. Y. Na, M. D. Xiong, and C. L. Ji, "Multi-UAV Collaborative Wireless Communication Networks for Single Cell Edge Users," *Mobile Networks & Applications*, vol. 27, no. 4, pp. 1578-1592, 2022.

[5] S. Gupta, S. D'Alessandro, A. Gupta, S. Stockar, and M. Canova, "A Computationally Efficient Algorithm for Perturbed Dynamic Programs (A-PDP)," *IEEE Control Systems Letters*, vol. 7, pp. 847-852, 2023.

[6] H. Kim, and B. I. Kim, "Hybrid Dynamic Programming with Bounding Algorithm for the Multi-profit Orienteering Problem," *European Journal of Operational Research*, vol. 303, no. 2, pp. 550-566, 2022.

[7] M. Liang, Y. H. Wang, and D. R. Liu, "An Efficient Impulsive Adaptive Dynamic Programming Algorithm for Stochastic Systems," *IEEE Transactions on Cybernetics,* vol. 53, no. 9, pp. 5545-5559, Sep. 2023.

[8] P. N. Loxley, and K. W. Cheung, "A Dynamic Programming Algorithm for Finding an Optimal Sequence of Informative Measurements," *Entropy*, vol. 25, no. 2, 2023.

[9] C. Ma, and W. Chung, "Visual Communication Design Based on Collaborative Wireless Communication Video Transmission," *Journal of Sensors*, vol. 2022, 2022.

[10] E. Mizutani, and S. Dreyfus, "On Using Dynamic Programming for Time Warping in Pattern Recognition," *Information Sciences*, vol. 580, pp. 684-704, 2021.

[11] R. M. Ramirez, M. L. A. Juarez, R. D. Mora, L. D. P. Morales, O. A. F. Mariles, A. M. Resendiz, E. C. Elizondo, and R. B. C. Paredes, "Operation Policies through Dynamic Programming and Genetic Algorithms, for a Reservoir with Irrigation and Water Supply Uses," *Water Resources Management*, vol. 35, no. 5, pp. 1573-1586, 2021.

[12] N. Saber, and N. Sulaiman, "Solving Quadratic Programming Problem Via Dynamic Programming Approach," *International Journal of Nonlinear Analysis and Applications*, vol. 13, no. 2, pp. 473-478, 2022.

[13] M. Shindler, N. Pinpin, M. Markovic, F. Reiber, J. H. Kim, G. P. N. Carlos, M. Dogucu, M. R. Hong, M. Luu, B. Anderson, A. Cote, M. Ferland, P. Jain, T. LaBonte, L. Mathur, R. Moreno, and R. Sakuma, "Student Misconceptions of Dynamic Programming: A Replication Study," *Computer Science Education*, vol. 32, no. 3, pp. 288-312, 2022.

[14] J. Stoj, A. L. Kampen, R. Cupek, I. Smolka, and M. Drewniak, "Industrial Shared Wireless Communication Systems-Use Case of Autonomous Guided Vehicles with Collaborative Robot," *Sensors*, vol. 23, no. 1, 2023.